3 Design

3.1 Design Context

3.1.1 Broader Context

The broader context of this design problem is situated around the concept of converting an executable program that exists for the purpose of making the transition between aboveground wiring (specifically electrical in nature) into an underground cabling setup.

The communities that this project is being designed for can be broken down into two entities being those in the electrical community that would be involved in boring of underground cabling, and the other community would be representatives of the professor client and EPRC. The communities that would be affected by this design would be those that will utilize the resultant software for determining overall bore sizes of the underground cabling. These communities will be affected purely on their usage of the web tool for determining proper bore size without any knowledge other than that of what wiring will need to be buried.

The societal need that this project addresses, is the need for easily accessible software for determining overall bore size of given wiring input that is an accurate representation of what the correct bore results should be. The expected use will be for the purpose of pricing and acquisition of appropriate amounts of wiring, meaning that the societal needs will be focused in that area specifically.

List of relevant considerations related to the project in each of the following areas:

Area	Description	Examples
Public health, safety, and welfare	A welfare connection between the project would be the incentive of easing the overall planning process for moving wiring underground to prevent powerlines from being affected by weather and causing damage or injury.	Reduces the possibility of having improper ducting/boring sizes making the move to underground wiring more stable of a wiring option.

Global, cultural, and social	The values and practices of the project and the process for the project would not be any realm that would cause concern regarding any affected communities (Iowa State University EPRC, Potential users).	This project is a web tool for specific calculations and visualizations. The process of creation and subsequent usage will follow programming standards for ease of use and user acceptability.
Environmental	An indirect impact created by this project would be, since it enables an ease of underground cable construction, the amount of tampering with top level earth would change as well as the amount of existing above ground cabling.	This would imply an increase in undergrounding boring for laying underground cabling, and maintaining said cable. The other effect would be less vertical above ground cabling structures that would either obstruct natural elements or become potential debris.
Economic	As the final project web tool is to be used in a planning and financing sense by potential clients, this project would have the ability to save labor and reduce human error. The only expense of the project would be by ISU for maintaining the code and server hosting the program.	This would mean that there would be a small cost to the hosting user (ISU), and a free tool for calculations for all other users that can ensure accurate planning of wire/duct sizes and corresponding amounts.

3.1.2 User Needs

List of Users:

The primary users of this project: ISU's EPRC acting as hosts and eventual software controllers, primary client groups consisting of companies with underground cabling needs (specifically, Alliant Energy)

The secondary users of this project: various contractors that would be working with either a primary user or another outside party, with the ultimate goal of setting up underground cable packages.

The tertiary users of this project would be every other user of the final product as it will be an openly available web tool with association to ISU's EPRC.

Individual User Needs:

The primary user, in regards to ISU's EPRC, requires a web based software that will be able to complete some basic wiring and bore size functions because an existing executable program was requested, by the other subcategory of primary users, to be implemented as an openly sharable program.

The other primary users need a program that can be openly available while easily and efficiently calculating optimal wire package size that can be shown as a visual representation with proof of optimal measuring. This is for the purpose of being able to correctly predict the sizing and amount of wires and ducts for purchasing, and to appropriately assess each individual jobs pricing for contractors.

The secondary users group need a way to have easy access to the algorithm without having to obtain the existing executable software from EPRC to prevent property violations, so that this group can confirm pricing with the primary users as well as gain the ability to create their own calculations.

The tertiary users group needs a way to gain access to quality software that can clearly show the results of circular objects embedded inside other circular objects because this could be a complicated mathematical problem that would be made simple from this software that is already being created for the use of the primary and secondary groups.

3.1.3 Prior Work/Solutions

A previous example of a solution that fulfills the same need as our project has been made at Iowa State, namely the Python-based desktop application created by our professor contact Mathew Wymore, however the Python app has some shortcomings. The Python application works well enough in that it retains a simple interface and can give accurate results quickly but lacks portability (as a static desktop application) and has no online connectivity. The web version of the application we intend to build this year will open the door for additional features and would be more user-friendly to a wide range of clients that may not want to set up a desktop application to get an accurate cost calculation for laying underground cables. A web version would also allow for the exporting of results in a more streamlined fashion compared to a screenshot of the Python application's input and output.

3.1.4 Technical Complexity

The design of this project will not simply entail the porting of the existing Python application into a webpage; there will be an analysis and redesign of the algorithm that determines cable best-fit in a given diameter pipe which will have to be verified against existing mathematical models, a new interface that can interact with our algorithm though a webpage, and the addition of new features like sharing results through links, storing results for future reference, and in the future offer mobile browser support, something the Python application cannot currently offer at all.

To implement such updates and improvements, we will have to build an updated model of the existing cable packing tool's algorithm to ensure optimal performance and accuracy. The algorithm will then need to have an interactive front-end, back-end, and database to allow users to interact with the app, retrieve results, and store/lookup previous calculations respectively. While existing technologies will aid us in building the structure for this application, such as JavaScript libraries to give us more front-end functionality or backend frameworks to allow faster querying of the algorithm, there are no plug-and-play solutions on the market that would fulfill the same goals as us building this tool ourselves.

3.2 Design Exploration

3.2.1 Design Decisions

Below is a list of some key design decisions that the team has made in relation to the solution that we have devised. The project is purely a software development project making a clear limit to software based decisions. It should be noted that the software will be hosted on an ISU server, and decisions related to said server have been made together with standard implementation and technology in mind.

1. We decided that in order to keep our project lightweight and easy to use, we will not be implementing a user account system. There was debate on being able to save the diagrams to a user account, but we have found alternatives that do not require as much involvement from the user.
2. We decided after meeting with Alliant Energy that what they envisioned for themselves and what we wanted to make were too disparate, and that we would continue on the project with our original vision. If there are things we can do to accommodate them, we will. However, if we were to match what they wanted, it would have been an entirely different project.
3. We were initially open to multiple technologies as there are not many external requirements when it came to technology. However, because of our familiarity with React and its broad applicability, we decided to use React for our project.

3.2.2 Ideation

For one design decision, describe how you ideated or identified potential options (e.g., lotus blossom technique). List at least five options that you considered.

3.2.3 Decision-Making and Trade-Off

The largest thing that affected our tech stack decisions was speed. Either speed of development or application speed. This eliminated a few choices right away that, while extensible and more feature-dense in the end, would take far too much setup and time to get off the ground.

The other decision was application speed. For that reason we chose a split frontend-backend that would present as quick of UI as possible and do number crunching as quickly as possible. For the frontend we landed on React JS because of its pretty and snappy feel and how easily it would be to display the data, and for the backend we ultimately landed on Go because of its builtin http server module and its speed. Compiled languages were always going to be the best choice, and Go had the best http implementation.

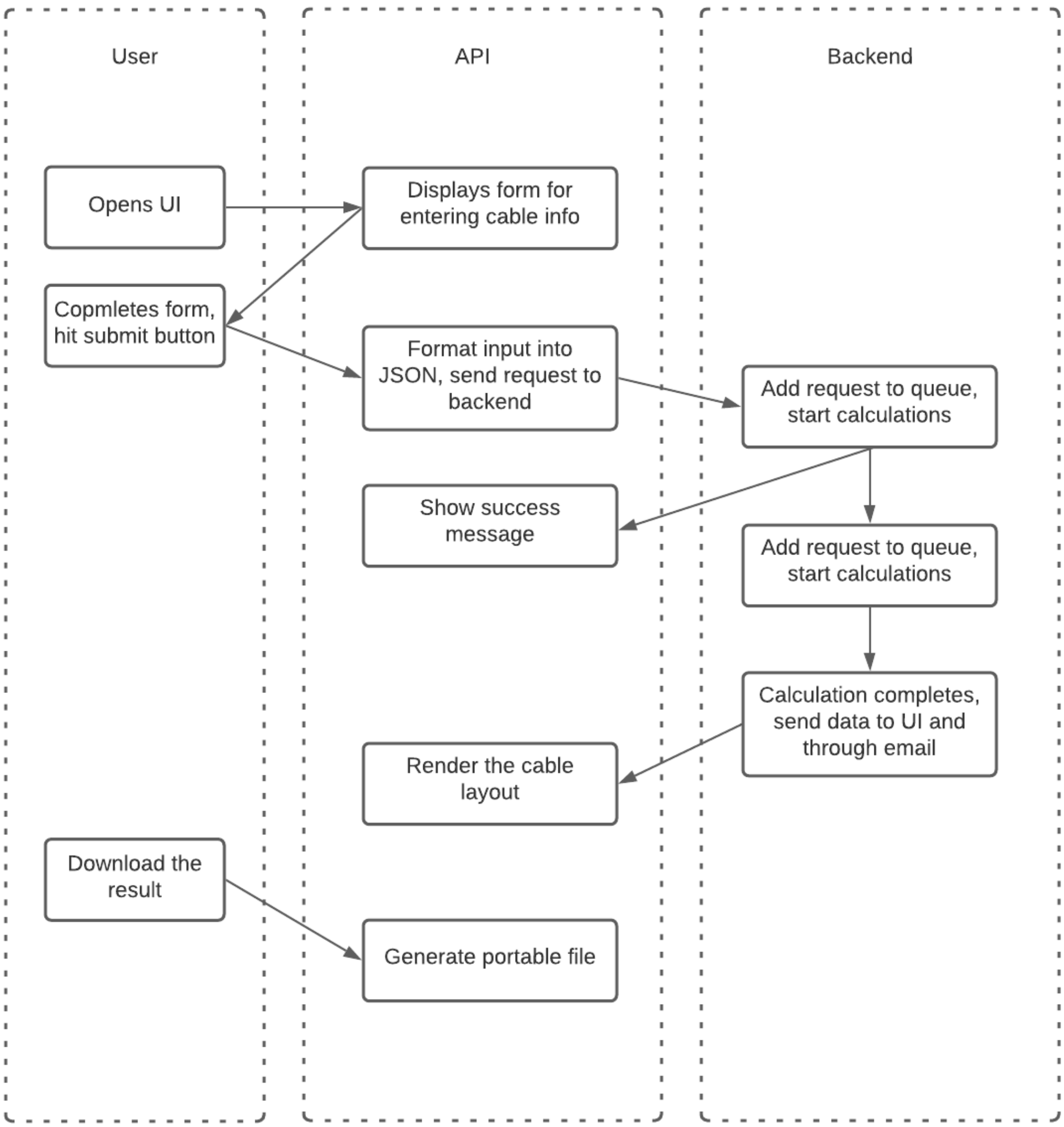
A final decision was our requirements for testing, internationalization, and accessibility. React has some very simple to use and extensible options for all of these requirements and presents the best options for a good user experience.

3.3 Proposed Design

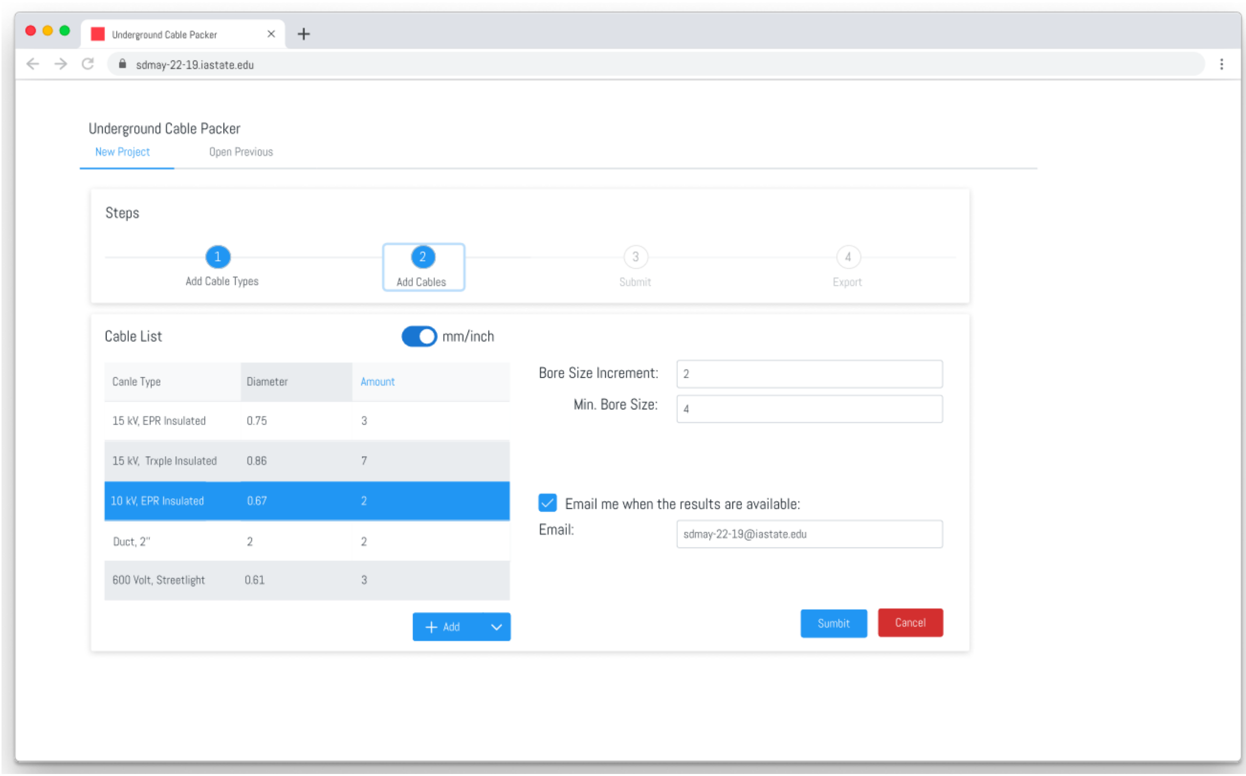
The following includes designs that have been implemented, tested, attempted, and mocked-up. These designs were created with the requirements of the project in mind as well as other general usability standards and visually appealing frontend plans.

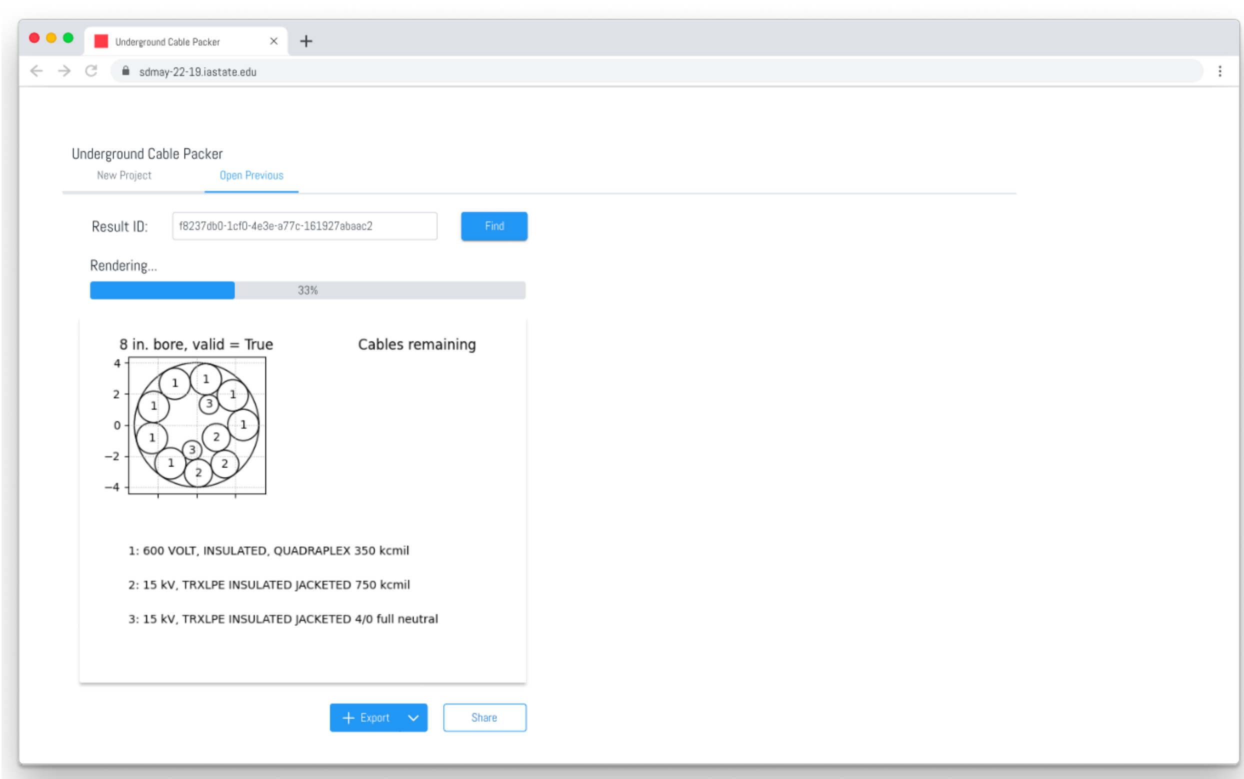
3.3.1 Design Visual and Description

API & User Interaction Diagram: The following diagram shows the interactions between the user, UI, and back-end APIs, with respect to time.



UI Mock-Ups:


Underground Cable Packer
sdmay-22-19.iastate.edu
Underground Cable Packer
New Project
Open Previous
Steps
1 Add Cable Types
2 Add Cables
3 Submit
4 Export
Cable List
mm/inch
Canle Type
Diameter
Amount
15 kV, EPR Insulated 0.75 3
15 kV, Trxple Insulated 0.86 7
10 kV, EPR Insulated 0.67 2
Duct, 2" 2 2
600 Volt, Streetlight 0.61 3
Add
Bore Size Increment: 2
Min. Bore Size: 4
Email me when the results are available:
Email: sdmay-22-19@iastate.edu
Sumbit
Cancel


Underground Cable Packer
sdmay-22-19.iastate.edu
Underground Cable Packer
New Project
Open Previous
Result ID: f8237db0-1cf0-4e3e-a77c-161927abaac2
Find
Rendering...
33%
8 in. bore, valid = True
Cables remaining
1: 600 VOLT, INSULATED, QUADRAPLEX 350 kcmil
2: 15 kV, TRXLPE INSULATED JACKETED 750 kcmil
3: 15 kV, TRXLPE INSULATED JACKETED 4/0 full neutral
Export
Share

3.3.2 Functionality

The design is intended to operate as an interactive website, which can be accessed by a modern browser. It will have fields in which a user can input their desired cables, ducts, and other underground utilities, and additionally, adjust the other parameters of the application. Once the user is satisfied with the selections they have made, the application will then perform the calculations and return a generated image and properties of the bore as well as how the cables will fit in the bore. Additionally, the application will return the next smallest bore size and display what cables would not fit should that bore size be used. The user may then opt to generate a link that can be shared to the results of the application.

We believe that the current design will satisfy the requirements laid out by the requirements documentation. While our design is still in the planning and research phase, and the UI is only in mockup, we believe that all requirements can be met.

3.3.3 Areas of Concern and Development

One concern being that a potential primary user that has input on the projects requirements (i.e. Alliant Energy) has shown desire to create a more specialized tool that would be specific to their system, but the main goal of this project is to create a generalized version of the predecessor that will be open and available to whoever wishes to use it. In light of this, we have developed a few possible solutions that we are looking into to resolve them. Such as for the generalization of Alliant Energy's requests and making it so the data can be exported to various different file types for usability.

A second concern we have identified is with software running the algorithm and concerns that it will not perform to the standards we have set for it, as in it may not run at speeds desired, slowing down the process. To avail this, we have considered rewriting the algorithm into a compiler language instead and even look into refactoring the code to further improve the speeds it can perform at.

Finally, we realised that scaling such a program to be correctly output and interacted with on a small screen such as a phone screen. This could have multiple ways to go about it, however we have not finalized which way this application will follow. Our current idea for it is to output a static picture at the top with details below, in contrast to having it on the side. Additionally using a front end structure that can determine screen size and adapt accordingly will be useful to assist in this.